INDOOR AIR QUALITY ASSESSMENT

New Central Elementary School
38 Pomeworth Street
Stoneham, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at New Central Elementary School in Stoneham, Massachusetts. This report addresses two separate issues related to indoor air quality: the potential impact(s) of hazardous waste reportedly located in the general school construction site and general indoor air quality related conditions existing within the school. BEHA staff received documentation related to the type of hazardous waste and remediation efforts related to the general school grounds in November 2002. These document were reviewed. The results of BEHA evaluation of this information is provided later in this report. BEHA staff also conducted site visits to the school to conduct air testing and to assess the general indoor air quality conditions. On April 24, 2002, a visit was made to this building by Mike Feeney, Director of BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program, to conduct an indoor air quality assessment. On June 13, 2002 the building was visited by Cory Holmes, Environmental Analyst for the ER/IAQ Program to conduct further air testing. Concerns of general air quality and in particular, to determine whether there were potential sources of hazardous materials (volatile organic compounds) that can penetrate the building from outside sources prompted the request.

The New Central School is a three-story, red brick building constructed in 2001. The third floor contains general classrooms, science, music, art and mechanical rooms. The second floor consists of general classrooms, gymnasium, media center, computer room and mechanical rooms. The first floor contains general classrooms, cafeteria/kitchen and school offices. Windows are openable throughout the building.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). A number of outdoor background TVOC measurements were taken for comparison to indoor levels.

Results

This school houses grades pre-K through 5 and has a student population of approximately 600 and a staff of approximately 50. Tests were taken during normal operations at the school and results appear in Tables 1-5.

Discussion

Ventilation

It can be seen from the tables that the carbon dioxide levels were below 800 parts per million (ppm) in all but three areas surveyed, indicating adequate air exchange by the ventilation system in most areas of the building. Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit (see Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. All univents were operable during both visits. Obstructions to airflow, such as cabinets and items placed in front of univent returns, were seen in a few classrooms. To function as designed, univent diffusers and univent returns must remain free of obstructions.

Mechanical exhaust ventilation is provided by ceiling or wall-mounted intake grills connected to rooftop exhaust fans. All exhaust vents were operating during the assessment.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. Information was not available as to if the ventilation system was balanced by a ventilation engineering firm. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself at levels measured in this building. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this occurs a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

Temperature readings ranged from 64 ^{0}F to 74 ^{0}F, some of which were below BEHA's recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{0}F to 78 ^{0}F in order to provide for the comfort of building occupants. BEHA staff received several occupant reports of poor ventilation/comfort complaints (see Tables). In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. The relative humidity in the building was below the BEHA recommended comfort range in all areas sampled during the April 24, 2002 visit. Relative humidity measurements ranged from 21 to 27 percent, with an outdoor relative humidity of 34 percent. Relative humidity levels during the June 13, 2002 visit ranged from 47 to 66 percent, which were above the BEHA comfort guidelines for some areas. Relative humidity measured indoors exceeded outdoor measurements (60%) in some cases. The increase in relative humidity can indicate that the exhaust system is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration).

Moisture removal is important since the sensation of heat conditions increases as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperatures rise, the addition of more relative humidity will make occupants feel hotter. If moisture is removed, the comfort of the individuals is increased. Removal of moisture from the air, however, can have some negative effects. The sensation of dryness and irritation is common in a low relative humidity environment.

While temperature is mainly a comfort issue, relative humidity in excess of 70 percent can provide an environment for mold and fungal growth (ASHRAE, 1989). During periods of high relative humidity (late spring/summer months), windows and exterior doors should be closed to keep moisture out; in addition, AHUs, univents and exhaust ventilation should be activated to control moist air in the building. Relative humidity levels in the building would be expected to drop during the winter months due to heating. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A few areas had water-stained ceiling tiles, which are evidence of roof or plumbing leaks (see Picture 1). Water-damaged ceiling tiles can provide a source of microbial growth and should be replaced after a water leak is discovered.

Several classrooms had a number of plants, some of which were located on top of univent air diffusers (see Picture 2). Moistened plant soil and drip pans can serve as a source of mold growth. Over-watering of plants should be avoided and staff should ensure that plants are located away from univents to prevent the aerosolization of dirt, pollen or mold.

Condensation drains (see Picture 3) from several univents were noted to exit the rear of the building at a height of over six feet. Drain water from this system tends to splatter, which wets the exterior brick. Repeated contact with water may result in water accumulation against the exterior wall, which can break down mortar around brick. Over time, freezing and thawing can create cracks and fissures in brickwork, ultimately compromising the integrity of the building envelope and providing a means of water entry into the building.

Other Concerns

Several other conditions were noted during the assessment, which can affect indoor air quality. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

The teacher's workroom contained a lamination machine, two photocopiers and a rizograph machine. Lamination machines can produce irritating odors during use. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). School personnel should ensure that local exhaust ventilation is activated while equipment is in use to help reduce excess heat and odors in these areas. It is worthwhile to note that no measurable levels of TVOCs were detected either inside or outside of the building.

A spray bottle of pesticide was observed in classroom 106 (see Picture 4). Only individuals with a pesticide applicator license can apply this product in a public school. Insecticides contain chemicals that can be irritating to the eyes, nose and throat. Under current

Massachusetts law effective November 1, 2001, the principles of integrated pest management (IPM) must be used to remove pests in schools (Mass Act, 2000). In addition, applicators of pesticides should be in full compliance with federal and state rules and regulations that govern pesticide use, including posting and notification requirements (333 CMR 13.10). Under no circumstances should pest-controlling products be applied by untrained personnel. Such products should not be applied prior to or during school hours.

Cleaning products were found on counter tops in classrooms (see Picture 5). Cleaning products contain chemicals (such as bleach or ammonia-related compounds), which can be irritating to the eyes, nose and throat. These items should be stored properly and out of the reach of students.

Hazardous Waste

Concerns were raised about the possible impact of hazardous waste in the general area of the school and its possible impact on indoor air quality. The material of concern found in the general area of the school was arsenic (MDEP, 2000). As identified on site maps, the bulk of the contamination was located in a rail bed behind as well as below the footprint of the school. It is unlikely that arsenic would impact the indoor air quality of this building for several reasons. First, the bulk of the areas of soil contamination were located downhill from the school and hence not likely to impact the upgradient indoor environment. Arsenic is a heavy metal that is fairly stable in soil. Likewise, in terms of groundwater contamination and its potential impact, the topography of the area would direct rainwater downhill along the rail bed. The rail bed is at a lower ground level than the school, which would prevent groundwater and potential soil pollutants from flowing towards the building. The topsoil in the area of the school was removed to a minimum depth of 3 feet in unpaved areas (MDEP, 2000). Arsenic is a solid material that is bound in soil. "[A]rsenic tends to concentrate and remain in upper solid layers [of contaminated soil]" (ATSDR, 2000). Removal of the soil would eliminate/significantly reduce remaining contamination. The areas around the building were paved with tarmac and concrete prior to the occupation of the school. This places a physical barrier between the environment and any remaining pollutants as it related to any exposure concern. For these reasons, it would be unlikely that arsenic would impact the indoor air quality of the building with the remediation steps that were implemented during construction.

At the time of these on-site assessments, BEHA staff did not have information that the contaminant of concern on school grounds was a non-volatile particulate (arsenic). Prior to acquiring this information, BEHA staff conducted air sampling for the most likely materials to impact the building. In the case of examining a building for an unknown chemical contaminant that could be within the indoor environmental, BHEA staff screen for materials that readily aerosolize when exposed to air [e.g., total volatile organic compounds (TVOCs)]. TVOCs are chemicals that consist of carbon that readily evaporate to form a vapor at room temperature. Since TVOCs would be considered most like to enter the building through the ventilation system or cracks in the walls or slab of the building, air monitoring with a PID is conducted inside and outside the building. All areas surveyed for TVOCs within the building were found to be equal to levels measured outdoors. These air monitoring results combined with the environmental data concerning the site remediation indicate that hazardous waste in this area does not appear to impact this building. Other activities cited in the previous sections of this report would be expect to be the origin of indoor air quality problems within this building.

Conclusions/Recommendations

In view of the findings at the time of our inspection, the following recommendations are made to improve general indoor air quality:

1. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy.
2. Consider having the systems balanced by an HVAC engineering firm every five years in accordance with SMACNA guidelines.
3. Remove all obstructions from univents and mechanical exhaust vents to facilitate airflow.
4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
5. Repair any existing water leaks and replace any remaining water-stained ceiling tiles. Examine the areas above these tiles for microbial growth. Disinfect areas of water leaks with an appropriate antimicrobial as needed.
6. Ensure plants are located away from univents in classrooms. Ensure drip pans are placed underneath plants in classrooms. Examine drip pans periodically for microbial growth and disinfect with an appropriate antimicrobial where necessary.

7. Ensure exhaust ventilation in teacher's workroom is operating during use of odor/heat producing equipment.
8. Change univent filters as per the manufacturer's instructions or more frequently if needed.
9. Remove the pesticide container from classroom 106. It is highly recommended that the principles of integrated pest management (IPM) be used to rid this building of pests.
10. Store cleaning products properly and out of reach of students.
11. Install flashing or a gutter system to dripping univent drain pipe(s) to carry water away from the building and prevent water pooling.
12. In order to provide self assessment and maintain a good indoor air quality environment on your building. Consideration should be give to adopting the US EPA document, "Tools for Schools", which can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
13. For further building-wide evaluations and advice on maintaining public buildings, see that resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

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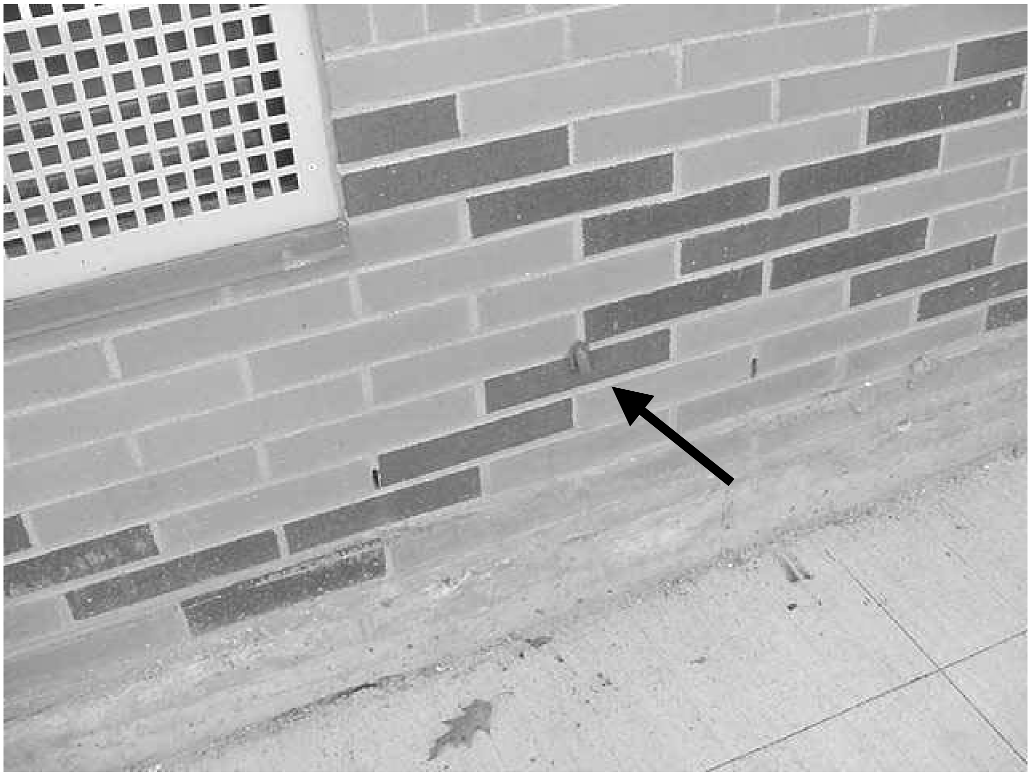
Picture 1

Water Damaged Ceiling Tiles in Hallway

Picture 2

Plants on/near Univent Air Diffuser

Picture 3



Univent Condensation Drain

Picture 4

Spray Bottle of Pesticide on Classroom Sink

Picture 5

Spray Cleaning Products on Classroom Sink

TABLE 1

Indoor Air Test Results – New Central Elementary School, Stoneham, MA – April 24, 2002

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	378	55	34					
101	535	70	27	0	yes	yes	yes	crates obstructing univent
103	464	70	26	2	yes	yes	yes	cabinet obstructing univent, window open
Gym	420	68	21	0	yes	yes	yes	
Media Center	451	69	22	1	yes	yes	yes	ceiling diffuser
Photocopier – 3rd flr	537	74	21	0	yes	yes	yes	laminator, rizograph, 2 photocopiers
photocopier – 2nd flr	510	71	21					
102	662	72	24	19				

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – New Central Elementary School, Stoneham, MA – June 13, 2002

Remarks	Carbon Dioxide *ppm	TVOC	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
							Intake	Exhaust	
Outside (Background)	426	0.0	58	60					weather conditions: cool, overcast, light breeze outside main entrance (west)
Parking Lot – SW		0.0							
Parking Lot – SE		0.0							
Parking Lot – N		0.0							
Parking Lot – NW		0.0							
Blacktop Playground – N		0.0							
Blacktop Playground – Center		0.0							
Blacktop Playground – S		0.0							
Pomworth Street Lot - S		0.0							
Pomworth Street Lot – N		0.0							
Pomworth Street Side Playground		0.0							

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – New Central Elementary School, Stoneham, MA – June 13, 2002

Remarks	Carbon Dioxide *ppm	TVOC	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
							Intake	Exhaust	
Main Office	652	0.0	64	66	4	no	yes	yes	
Lobby	560	0.0	66	66			yes		
Cafeteria	486	0.0	67	64	0	yes	yes	yes	
100A	541	0.0	67	63	1	no	yes	yes	
100C	546	0.0	67	61	0	yes	yes	yes	
101	622	0.0	68	60	2	yes	yes	yes	19 occupants gone ~20 mins.
102	641	0.0	68	59	29	yes	yes	yes	door open
106	645	0.0	69	58	3	yes	yes	yes	pyrethrin based insect spray on sink countertop
103	906	0.0	70	54	23	yes	yes	yes	
105	654	0.0	70	52	2	yes	yes	yes	
104	750	0.0	70	52	1	yes	yes	yes	plants on univent, radiator making noise, 19 occupants gone ~20 mins.

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TABLE 4

Indoor Air Test Results – New Central Elementary School, Stoneham, MA – June 13, 2002

Remarks	Carbon Dioxide *ppm	TVOC	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
							Intake	Exhaust	
107	579	0.0	70	50	2	yes	yes	yes	
108	515	0.0	70	50	1	no	yes	yes	dirt/dust accumulation on return vent
300B	625	0.0	71	50	1	no	yes	yes	complaints of stuffiness, dust on flat surfaces, small photocopier, dry erase board cleaner
300	582	0.0		49	0	yes	yes	yes	5th grade/3rd floor not present during assessment
303	578	0.0	71	50	0	yes	yes	yes	plants on univent, spray cleaning product on countertop
306	572	0.0	71	49	0	yes	yes	yes	plastic drip pans in univent, cleaning product on univent
309	495	0.0	70	47	0	yes	yes	yes	2 photocopiers
308	488	0.0	70	48	0	yes	yes	yes	
209	500	0.0	70	49	0	yes	yes	yes	2 photocopiers
203	1077	0.0	72	53	25	yes	yes	yes	univent-utility holes-sealed drain-gravity, drain pan drains correctly

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Comfort Guidelines

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Indoor Air Test Results – New Central Elementary School, Stoneham, MA – June 13, 2002

Remarks	Carbon Dioxide *ppm	TVOC	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
							Intake	Exhaust	
201	888	0.0	73	49	21	yes	yes	yes	
200 – Library	580	0.0	71	47	29	yes	yes	yes	
2^{nd} flr. Hallway-outside gym									10 water-damaged CT
Gym	465	0.0	69	47	1	yes	yes	yes	inconsistent temperatures, noise complaints
Cafeteria (full)	547	0.0	70	51	~100	yes	yes	yes	ventilation off in gym – reportedly for several weeks

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